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Added Sugar Intake and Cardiovascular Risk Factors in Children and Adolescents: A Cross-Sectional Analysis of NHANES 2017–March 2020 Data

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Abstract

Background: There are many factors that increase the risk of cardiovascular diseases (CVD) including dyslipidemia, elevated blood pressure, and obesity, and they are increasingly recognized in pediatric populations. Early detection of modifiable risk factors such as body mass index (BMI) and dietary sugar intake facilitates preventive interventions. The National Health and Nutrition Examination Survey (NHANES) provides a dataset well-suited for such analyses.

Objective: To examine the relationships between BMI, dietary sugar intake, total caloric intake, and cardiovascular risk markers including serum triglycerides, LDL cholesterol, HDL cholesterol, and systolic blood pressure in a sample of children and adolescents.

Methods: A cross-sectional analysis was conducted using the NHANES 2017–March 2020 pre-pandemic cohort. The study includes 119 participants aged 12 to 17 years with complete data across all analytic variables (55 males, 64 females; mean age 14.7 ± 1.6 years). BMI was classified using CDC Growth Chart BMI-for-age percentile cutoffs. Pearson correlation coefficients and multiple linear regression analyses were performed using Python 3.x.

Results: BMI demonstrated significant but weak-to-moderate negative correlation with HDL cholesterol ($r = -0.389$, $p < 0.001$) and significant positive correlations with triglycerides ($r = 0.369$, $p < 0.001$) and LDL cholesterol ($r = 0.336$, $p < 0.001$). Using CDC growth chart classification, 55.5% of participants were classified as healthy weight, 23.5% as obese, 19.3% as overweight, and 1.7% as underweight; combined, 42.9% had elevated BMI. Dietary sugar intake was positively associated with LDL cholesterol ($r = 0.210$, $p = 0.022$). In multiple linear regression, BMI was the dominant independent predictor of triglycerides ($\beta = 2.118$, $p < 0.001$) and HDL cholesterol ($\beta = -0.686$, $p < 0.001$), while sex was a significant predictor of systolic blood pressure ($\beta = -7.633$, $p < 0.001$).

Conclusion: BMI is a strong predictor of adverse cardiovascular markers in children and adolescents, particularly reduced HDL and elevated triglycerides and LDL cholesterol. The association between dietary sugar and LDL warrants further investigation. These findings emphasize the importance of early lifestyle intervention to reduce the long-term burden of cardiovascular disease.

Keywords: Cardiovascular Risk Factors; Children; Adolescents; BMI; CDC Growth Charts; Dietary Sugar; Dyslipidemia; NHANES; Cross-Sectional Study.

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1. Introduction

Cardiovascular diseases (CVD) are a group of disorders affecting the heart and blood vessels. CVD are leading causes of morbidity and mortality worldwide, and evidence suggests that their pathological roots often originate during childhood and adolescence. Risk factors including dyslipidemia and hypertension are now increasingly recorded in pediatric populations, raising significant public health concerns.[1]

One of the most modifiable risk factors in pediatric populations is excess body weight, most commonly measured through the body mass index (BMI). In children and adolescents, BMI must be age- and sex-specific, as body fat distribution and composition change during growth and development.[9] The Centers for Disease Control and Prevention (CDC) Growth Charts provide validated BMI-for-age percentile cutoffs specifically designed for children and adolescents aged 2 to 20 years, categorizing weight status as underweight (<5th percentile), healthy weight (5th to <85th percentile), overweight (85th to <95th percentile), and obese (≥95th percentile).[10] Elevated BMI in children is associated with an adverse lipid profile — including high LDL cholesterol, high triglycerides, and low HDL cholesterol — as well as elevated blood pressure, all of which are recognized risk factors for atherosclerotic cardiovascular disease.[11,12]

Dietary habits, particularly added sugar consumption, represent another important modifiable determinant of cardiovascular health. Increased sugar intake, especially in the form of fructose, has been associated with increased hepatic lipogenesis, hypertriglyceridemia, insulin resistance, and systemic inflammation.[13] In the United States, dietary sugar consumption among children and adolescents remains high, with sugar-sweetened beverages representing a major source.[14,15] Despite this, the specific relationship between dietary sugar intake and cardiovascular risk markers in pediatric populations has not been fully characterized, particularly when accounting for key confounders such as total caloric intake, BMI, age, and sex.

The National Health and Nutrition Examination Survey (NHANES), conducted by the National Center for Health Statistics (NCHS) of the CDC, provides an appropriate database for investigating these relationships. The pre-pandemic 2017–March 2020 cohort provides comprehensive data including demographics, anthropometric measurements, dietary recall, blood pressure readings, and laboratory results from a nationally representative sample of the United States population.[5]

This study aims to examine the associations between BMI classified using the CDC Growth Chart, dietary sugar intake, total caloric intake, and cardiovascular risk markers — including serum triglycerides, LDL cholesterol, HDL cholesterol, and systolic blood pressure — in a sample of 119 children and adolescents aged 12 to 17 years drawn from the NHANES 2017–March 2020 dataset. These findings are intended to contribute to the growing body of literature highlighting the importance of early lifestyle interventions in reducing the long-term burden of cardiovascular disease.

2. Methods

2.1. Study Design and Data Source

A cross-sectional design was conducted using available data from the NHANES 2017–March 2020 pre-pandemic cohort. NHANES is a nationally representative, population-based survey conducted by the NCHS using a complex, stratified, multistage probability sampling design. NHANES data include demographic, dietary intake, physical examination, and laboratory results. As these data are publicly available and de-identified, this study was exempt from institutional ethics review.[5]

2.2. Study Population and Eligibility Criteria

The target population was children and adolescents aged 12 to 17 years. Inclusion criteria required complete and valid data for all analytic variables: BMI, systolic blood pressure, serum triglycerides, LDL cholesterol, HDL cholesterol, total dietary sugar intake, and total energy intake. Participants with missing values in any of these variables were excluded. After applying eligibility criteria, the final analytic sample comprised 119 participants (55 males, 64 females; mean age 14.7 ± 1.6 years).

2.3. Variables and Data Collection

Data were collected from six NHANES data files and merged using the unique participant identifier (SEQN). The variables collected included: (1) demographics — age, sex, race/ethnicity; (2) anthropometric measurements — BMI, height, weight; (3) blood pressure readings; (4) serum triglycerides and LDL cholesterol; (5) HDL cholesterol; and (6) 24-hour dietary recall data, from which total daily sugar intake, energy intake, and fat intake were derived. The first systolic blood pressure reading was used as the primary blood pressure measure, consistent with standard NHANES analytic practice.

2.4. BMI Classification

BMI was classified using the CDC Growth Charts for the United States, which provide age- and sex-specific BMI-for-age percentile cutoffs validated for children and adolescents aged 2 to 20 years.[10] Participants were classified into four groups: underweight (BMI-for-age <5th percentile), healthy weight (5th to <85th percentile), overweight (85th to <95th percentile), and obese (≥95th percentile). This approach is recommended by the CDC and the American Academy of Pediatrics for pediatric BMI classification, as it accounts for the physiological changes in body fat across age groups and between sexes during growth and development.[10,17]

2.5. Statistical Analysis

Statistical analyses were performed using Python 3.x (pandas, scipy.stats, numpy). Continuous variables were reported as means ± standard deviation (SD); categorical variables as frequencies and percentages. Bivariate associations between continuous variables were assessed using Pearson correlation coefficients (r). Multiple linear regression models were constructed using ordinary least squares (OLS), with triglycerides, LDL cholesterol, HDL cholesterol, and systolic blood pressure as separate dependent variables. Predictors included age, sex, and BMI in all models. Sex-stratified subgroup analyses were conducted for the BMI–HDL association. Statistical significance was defined as $p < 0.05$ (two-tailed). No adjustment for multiple comparisons was applied given the exploratory nature of this study; accordingly, all findings should be considered hypothesis-generating.

3. Results

3.1. Sample Characteristics

A total of 119 children and adolescents met eligibility criteria and were included in the analytic sample. The sample comprised 55 males (46.2%) and 64 females (53.8%), with a mean age of 14.7 ± 1.6 years (range: 12–17 years). The sample was racially and ethnically diverse: 27 (22.7%) Mexican American, 9 (7.6%) Other Hispanic, 33 (27.7%) Non-Hispanic White, 31 (26.1%) Non-Hispanic Black, 10 (8.4%) Non-Hispanic Asian, and 9 (7.6%) other or multiracial.

Table 1 Baseline characteristics of the analytic sample (n = 119).

Characteristic	**Value / n (%)**	**SD / Range**
Total participants	119	—
Age (years), mean ± SD	14.7 ± 1.6	(range 12–17)
Sex — Male	55 (46.2%)	—
Sex — Female	64 (53.8%)	—
Race/Ethnicity		
Mexican American	27 (22.7%)	—
Other Hispanic	9 (7.6%)	—
Non-Hispanic White	33 (27.7%)	—
Non-Hispanic Black	31 (26.1%)	—
Non-Hispanic Asian	10 (8.4%)	—
Other/Multiracial	9 (7.6%)	—
BMI (kg/m^2), mean ± SD	24.6 ± 6.9	
Underweight (<5th percentile)	2 (1.7%)	—
Healthy Weight (5th–<85th percentile)	66 (55.5%)	—
Overweight (85th–<95th percentile)	23 (19.3%)	—
Obese (≥95th percentile)	28 (23.5%)	—

Dietary Intake		
Total energy intake (kcal/day)	1,933.2	± 885.2
Total sugar intake (g/day)	111.2	± 68.4
Cardiometabolic Markers		
Triglycerides (mg/dL)	71.4	± 39.8
LDL Cholesterol (mg/dL)	83.6	± 22.4
HDL Cholesterol (mg/dL)	52.1	± 12.0
Systolic Blood Pressure (mmHg)	108.9	± 9.4

The mean BMI was 24.6 ± 6.9 kg/m^2. Using CDC Growth Chart BMI-for-age percentile cutoffs, 66 participants (55.5%) were classified as healthy weight, 28 (23.5%) as obese (≥95th percentile), 23 (19.3%) as overweight (85th to <95th percentile), and 2 (1.7%) as underweight (<5th percentile). A total of 51 participants (42.9%) had elevated BMI (overweight or obese), demonstrating a high prevalence of excess weight in this nationally representative sample.

Mean dietary sugar intake was 111.2 ± 68.4 g/day and mean total energy intake was 1,933.2 ± 885.2 kcal/day. Mean values for cardiometabolic markers were: triglycerides 71.4 ± 39.8 mg/dL, LDL cholesterol 83.6 ± 22.4 mg/dL, HDL cholesterol 52.1 ± 12.0 mg/dL, and systolic blood pressure 108.9 ± 9.4 mmHg. Full baseline characteristics are presented in Table 1.

3.2. Associations Between BMI and Cardiovascular Risk Markers

BMI demonstrated a significant but weak-to-moderate negative correlation with HDL cholesterol ($r = -0.389$, $p < 0.001$), indicating that higher BMI was strongly associated with lower levels of this cardioprotective lipoprotein. Significant positive correlations were observed between BMI and serum triglycerides ($r = 0.369$, $p < 0.001$) and between BMI and LDL cholesterol ($r = 0.336$, $p < 0.001$), reflecting a more atherogenic lipid profile with increasing BMI. The association between BMI and systolic blood pressure was in a positive direction ($r = 0.057$) but did not reach statistical significance ($p = 0.542$). These findings suggest that BMI is most strongly and consistently associated with lipid-related cardiovascular risk markers rather than blood pressure.

3.3. Associations Between Dietary Sugar Intake and Cardiovascular Risk Markers

Table 2 Pearson correlation coefficients between key study variables (n = 119). * p < 0.05; NS = not significant.

Variable Pair	**r**	**p-value**	**n**	**Significance**
BMI ↔ Cardiovascular Markers				
BMI ↔ HDL Cholesterol	−0.389	<0.001	119	p < 0.001 *
BMI ↔ Triglycerides	+0.369	<0.001	119	p < 0.001 *
BMI ↔ LDL Cholesterol	+0.336	<0.001	119	p < 0.001 *
BMI ↔ Systolic BP	+0.057	0.542	119	NS
Dietary Sugar ↔ Cardiovascular Markers				
Sugar ↔ LDL Cholesterol	+0.210	0.022	119	p < 0.05 *
Sugar ↔ Systolic BP	+0.145	0.116	119	NS
Sugar ↔ HDL Cholesterol	−0.058	0.531	119	NS
Sugar ↔ Triglycerides	+0.031	0.740	119	NS
Sugar ↔ BMI	+0.150	0.104	119	NS
Other Dietary Associations				
Caloric Intake ↔ BMI	+0.273	0.003	119	p < 0.05 *
Fat Intake ↔ LDL	+0.026	0.780	119	NS

Dietary sugar intake was significantly and positively correlated with LDL cholesterol (r = 0.210, p = 0.022), suggesting that higher sugar consumption is associated with higher levels of this atherogenic lipoprotein. This finding should be interpreted cautiously as hypothesis-generating, given the absence of correction for multiple comparisons. No statistically significant associations were found between dietary sugar intake and triglycerides (r = 0.031, p = 0.740), HDL cholesterol (r = −0.058, p = 0.531), or systolic blood pressure (r = 0.145, p = 0.116). No significant association was observed between dietary sugar and BMI (r = 0.150, p = 0.104), though the trend was positive. All bivariate correlation results are summarized in Table 2.

3.4. Association Between Caloric Intake and BMI

Total caloric intake was significantly and positively associated with BMI (r = 0.273, p = 0.003), indicating that higher daily caloric intake is associated with higher body mass index in this sample. Total fat intake showed no significant association with LDL cholesterol (r = 0.026, p = 0.780), suggesting that dietary fat quantity does not strongly predict atherogenic dyslipidemia in this dataset.

3.5. Multiple Linear Regression: Predictors of Cardiometabolic Markers

Multiple linear regression models were conducted to assess the independent contributions of BMI, age, and sex to each cardiometabolic outcome. In the model predicting serum triglycerides, BMI emerged as the dominant and statistically significant predictor (β = 2.118, SE = 0.502, p < 0.001), while age (β = 1.219, p = 0.565) and sex (β = −8.512, p = 0.219) did not reach significance. The model explained 15.1% of variance in triglycerides (R^2 = 0.151). For HDL cholesterol, BMI was again the primary predictor (β = −0.686, SE = 0.144, p < 0.001), with females having significantly higher HDL than males (β = +6.504 for female sex, p = 0.001); the model explained 23.9% of variance (R^2 = 0.239). For systolic blood pressure, sex was the dominant predictor (β = −7.633, SE = 1.589, p < 0.001, indicating lower systolic BP in females), while BMI (β = 0.100, p = 0.391) and age (β = 0.573, p = 0.242) did not independently predict systolic BP (R^2 = 0.187). Regression coefficients for the triglycerides model are presented in Table 3.

Table 3 Multiple linear regression: predictors of serum triglycerides (n = 119). * p < 0.05. †Dietary sugar was not included in the triglycerides regression model due to absence of a significant bivariate association; see Table 2.

Predictor	β (Unstandardized)	SE	p-value	Interpretation
BMI (kg/m^2)	+2.118	0.502	<0.001 *	Dominant predictor
Age (years)	+1.219	2.111	0.565	Not significant
Sex (Male=1, Female=2)	−8.512	6.886	0.219	Adjusted covariate
Dietary Sugar (g/day)	—	—	—	Not included†
Model R^2	0.151			

3.6. Sex-Specific Analysis: BMI and HDL Cholesterol

Sex-specific Pearson correlation analyses revealed that the inverse association between BMI and HDL cholesterol was statistically significant in both males (r = −0.294, p = 0.029, n = 55) and females (r = −0.509, p < 0.001, n = 64). The magnitude of the association was substantially stronger among females, suggesting that elevated BMI may have a greater adverse impact on HDL levels in girls within this age group. These results are presented in Table 4.

Table 4 Sex-specific Pearson correlation: BMI and HDL cholesterol. * p < 0.05.

Variable Pair	Group	r	p-value	n	Sig.
BMI ↔ HDL Cholesterol	Males	−0.294	0.029	55	*
BMI ↔ HDL Cholesterol	Females	−0.509	<0.001	64	*

4. Discussion

This cross-sectional study provides insight into cardiovascular risk factors in a nationally representative sample of children and adolescents drawn from the NHANES 2017–March 2020 pre-pandemic cohort, using CDC Growth Chart classification for pediatric weight assessment.

Supporting existing literature,[11,12] BMI emerged as the strongest and most consistent predictor of adverse cardiovascular risk markers, demonstrating significant associations with HDL cholesterol, triglycerides, and LDL cholesterol. The strongest observed association was the inverse relationship between BMI and HDL cholesterol ($r = -0.389$), which was significant across both sexes but markedly stronger among females ($r = -0.509$). This sex difference may reflect hormonal influences on lipoprotein metabolism during puberty, including the effects of estrogen on HDL particle production and clearance.[18] The finding that approximately 42.9% of participants had elevated BMI underscores the ongoing public health challenge of pediatric obesity and its cardiovascular consequences.[20]

The significant positive correlation between dietary sugar intake and LDL cholesterol ($r = 0.210$, $p = 0.022$) represents a noteworthy finding, though it should be interpreted as hypothesis-generating given the exploratory nature of this analysis and the absence of adjustment for multiple comparisons. While the precise mechanism remains under investigation, excessive sugar intake — particularly fructose — is thought to upregulate hepatic very-low-density lipoprotein (VLDL) synthesis, thereby elevating LDL cholesterol through lipoprotein remodeling.[13] The absence of a significant association between dietary sugar and triglycerides somewhat contrasts with published evidence linking fructose consumption to hypertriglyceridemia,[13] and may reflect the small sample size, reliance on a single 24-hour dietary recall, and the cross-sectional design.[3]

Notably, the association between BMI and systolic blood pressure did not reach statistical significance at the bivariate level ($r = 0.057$, $p = 0.542$), contrasting with findings from larger pediatric cohort studies.[4] This may be attributable to the relatively narrow blood pressure range in the sample, limited statistical power, or regression dilution from single-occasion measurement.[7] In the regression model, sex was a stronger predictor of systolic blood pressure than BMI, with females demonstrating significantly lower systolic BP — a pattern consistent with known sexual dimorphism in blood pressure trajectories during adolescence.

The positive association between total caloric intake and BMI ($r = 0.273$, $p = 0.003$) reinforces the importance of energy balance in determining adiposity in pediatric populations, and aligns with public health guidance to monitor total energy intake and dietary quality in children.[16]

Limitations

Several limitations should be acknowledged. First, the cross-sectional design precludes establishing causal or directional relationships. Second, the sample of 119 participants is relatively small, limiting statistical power and precluding subgroup analyses by age group, race/ethnicity, or pubertal stage. Third, dietary data were obtained from a single 24-hour dietary recall, which may not capture habitual intake and is subject to recall bias and day-to-day variation. Fourth, unmeasured confounders — including physical activity, screen time, socioeconomic status, and pubertal stage — may affect the observed associations. Fifth, NHANES complex survey sampling weights were not applied in this exploratory analysis; weighted analyses may yield different estimates and should be considered in future research. Sixth, no correction for multiple comparisons was applied; accordingly, the sugar–LDL association ($p = 0.022$) should be regarded as hypothesis-generating only and may not survive formal correction.

5. Conclusion

This cross-sectional study demonstrates that BMI is a consistent and strong predictor of adverse cardiovascular risk markers in children and adolescents, particularly reduced HDL cholesterol and elevated serum triglycerides and LDL cholesterol. The finding that 42.9% of the sample was classified as overweight or obese highlights the pressing importance of pediatric weight management strategies. Dietary sugar intake showed a significant bivariate association with LDL cholesterol that warrants further investigation in larger, longitudinal studies employing more comprehensive dietary assessment methods.

Future research should incorporate larger, more representative samples with complete dietary and laboratory data, and use longitudinal designs to establish temporality. The use of food frequency questionnaires (FFQ) rather than single 24-hour recalls is recommended to better capture habitual nutritional intake and strengthen dietary data validity. Taken together, these findings emphasize the importance of early monitoring of weight status and dietary habits in pediatric populations as part of a comprehensive strategy to reduce the lifetime burden of cardiovascular disease.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

Statement of ethical approval

This study used publicly available, de-identified data from the National Health and Nutrition Examination Survey (NHANES) and was exempt from institutional review board (IRB) approval per the National Center for Health Statistics (NCHS) data use guidelines. No personally identifiable information was accessed or used.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

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